**IMAGING VIGNETTE**

**Integrated 3D Echo-X Ray to Optimize Image Guidance for Structural Heart Intervention**

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Real-time, 3-dimensional transesophageal echocardiography (RT 3D TEE) is now used routinely in conjunction with x-ray fluoroscopy to guide percutaneous structural heart disease (SHD) interventions. Unlike fluoroscopy, RT 3D TEE provides excellent detail of 3D anatomy and soft tissue structures, and provides “live” inaprocedure guidance. A novel 3D echo-x-ray navigation system that successfully...

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**FIGURE 1** Merging Echo and X-ray With 2D to 3D Image Registration

The registration is accomplished by aligning the projection of transesophageal echocardiographic (TEE) data into the 2-dimensional (2D) x-ray coordinate system on the basis of an automatic tracking of the TEE probe, a process termed image-based tracking, which requires no structural modification of the TEE probe (1). During the registration process, the projection of a digitally reconstructed 3D model of the TEE probe (A) is overlaid and matched against the real-time probe in orthogonal views (B and C). The green digitally reconstructed image of the probe confirms registration is active. When the probe is activated for 3D acquisition, the purple color sector demonstrates the acquired region of interest (D). This initial process of registration takes 15 to 30 s. As the C-arm is moved for subsequent fluoroscopic acquisitions, the digitally reconstructed projection is automatically repositioned, tracking the TEE probe, and all the 3D TEE images are updated and displayed on the basis of the new gantry angle.

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integrates TEE imaging and fluoroscopic images, on the basis of a 2D to 3D image registration technique, has been developed and is now commercially available.

Registration of RT 3D TEE and fluoroscopy provides real-time simultaneous interactive imaging in 2 modalities that are specifically used for the guidance of SHD interventions. This iPix imaging series describes our initial experiences during the development of this navigation system, including a library of case examples with illustrative images. Several representative examples are presented in Figures 1 to 4. An ASD closure using the integrated features of the system is demonstrated in Online Video 1. Perceived benefits include enhanced anatomic understanding and improved delivery system navigation and improved multidisciplinary team communication.
The use of real-time, 3-dimensional transesophageal echocardiography (RT 3D TEE) has been well described for guidance during mitral valve interventions in which the catheter navigation is often more complex. Specifically, for MitraClip (Abbott Structural Heart, Menlo Park, California) procedures, the initial hurdle usually involves a strategically positioned transseptal puncture. Following this, the catheter navigation and alignment within the mitral annulus were facilitated with x-ray and 3D TEE overlay. (A) Simultaneous overlay of 2D echo images with the concomitant fluoroscopic view during transseptal catheterization. (B) MitraClip positioning. The c-arm concordant view is overlaid with the registered x-ray to create a true hybrid view.

Simultaneous views allow navigation of the catheters from the left atrium into the left ventricle. In addition, the marker feature can be used to identify the site of paravalvular leak in both the fluoroscopic and echocardiographic projection, guiding the team to the approximate location of the leak. Markers identifying the surrounding structures, such as the left atrial appendage and aortic valve were used for spatial orientation purposes to avoid the “lost in 3D space” phenomenon that is common when working in unorthodox views. In this example the “Target” or site of the leak is not readily identifiable in 2D imaging. (A) The left atrial view with the red arrow highlighting the catheter crossing the defect. (B) The same target but visualized from the left ventricle. (C) The c-arm view, positioned to project a “side view” of the mitral valve to allow visualization of the wire crossing into the ventricle. (D) The corresponding fluoroscopic view has better hardware definition for delivery of the device, but lacks the detail necessary to navigate the catheter in 3D space that is required for this procedure. All 4 views were presented simultaneously to the interventionalist. Abbreviations as in Figures 1 and 3.
REFERENCE


KEY WORDS 3D TEE, imaging guidance, structural heart interventions

APPENDIX For an accompanying video and legend, please see the online version of this article.